Effect of Different Cereal Blends on the Quality of *Injera* a Staple Food in the Highlands of Ethiopia

Addis Abraha* and Fetien Abay

Mekelle University, College of Dryland Agriculture and Natural Resources, department of Dryland Crop and Horticultural sciences (*addisabr@yahoo.com).

ABSTRACT

Majority of the Ethiopian population are dependent on tef (*Eragrostis tef (Zucc) trotter*) flour to make *injera*, a staple food in Ethiopia, although *injera* could be made from different cereals. The price of tef, however, is high and the yield potential of the crop is low. Thus, searching for alternative cheaper grains and developing a blend of different cereal flours that can produce *injera* of acceptable quality and improved nutritional value would be important. This study was conducted to evaluate the sensory quality of *injera* made from a blend of different cereals (Tef, barley, sorghum and maize) with differing ratios: 100, 75, 50 and 25%. The sensory evaluation of *injera* was conducted at Mekelle University in a replicated trial. The results revealed significant differences among the cereal flour blends in *injera* texture, mouth feeling, suppleness and overall rate, while colour, taste and the appearance of *injera* surface gas holes were non-significant. *Injera* made from 100% tef flour got the highest preference rank in terms of the texture, mouth feeling, suppleness and overall ratings. *Injera* made from 50:50 tef + barley blend was the second best in both texture and suppleness followed by 50:50 tef + sorghum, 50: 50 tef + maize blends and tef + barley + sorghum blend of equal ratio. Similarly, results from blend of tef + barley + maize, tef + sorgum + maize and from the four varietal blends in equal ratios produced very good *injera* quality. From the study results *injera* quality ranked next to sole tef (tef + barley, tef + sorghum, tef + maize in 50:50 blends and tef + barley + sorghum in equal ratios) could be used as an alternative option for *injera* utilization and could provide nutritional and dietary benefits to consumers.

Keywords: Sensory attributes, *Injera* quality, cereal flour blends, Tef, Ethiopia.

1. INTRODUCTION

Agriculture is the main stay of the Ethiopian economy and accounts for 42% of the Gross Domestic Product (GDP) and 84% of the total exports and creates employment for 77% of the total population (ATA, 2015). The population of Ethiopia is increasing at a faster rate (2.5%), and with a population of 94.35 million, it is the second largest population in Africa next to Nigeria (Central Statistical Agency (CSA), 2017a). It is a priority of the government to increase agricultural production and productivity to improve food security of the increasing population. In the year 2016/2017 main crop season, production of cereal grains covers 81.27% of total area under grain crops production (10.2 million ha), with tef (*Eragrostis tef*), maize, sorghum, wheat and barley being the major cereals that cover the highest area coverage, respectively of all crops (CSA, 2017b). However, Ethiopia is still facing challenges of food security as observed in the

year 2015/2016 drought problem, where around 12 million people from food insecure households were in need of food assistance.

Despite Ethiopia's richness in diversity for many cultivated crop varieties; there is a critically concerning issue that the food habits of most Ethiopian population need a change through research. Because majority of the Ethiopian population are dependent on flat bread (*injera*) made mainly from tef, while there are diverse crop varieties to use. Even the awareness of the consumers both in rural and urban areas on the benefits of diverse food system is very limited.

Although *injera* could be made from fermented dough of different cereals such as tef, barley, sorghum, wheat and maize, *injera* from tef is still commonly preferred and daily consumed by majority of the people (Zegeye, 1997; Yetneberk et al., 2004). This is due to its softer texture, preferred taste and colour (Yetneberk et al., 2005; Abraha et al., 2013). Normally, *injera* with uniformly distributed surface gas holes, soft plumpness, non-sticky and having slightly sweet taste is commonly preferred by *injera* consumers (Abraha et al., 2013).

Exporting tef grain from Ethiopia is legally restricted due to high consumption demand within the country; however, fresh *injera* made from tef is being exported to Ethiopian Diaspora in the US, Middle East and Europe (Abraha et al., 2013). This aggravates the price of tef which becomes unaffordable to low income citizens. Thus considering the increased price of tef grain in the local market and its low yield potential, searching for less expensive grains such as barley, sorghum, maize and wheat that can be used in blend with tef has become very important. Moreover, foods prepared from different cereal blends could provide better nutritional and dietary values for health, besides food security. For instance barley has high beta-glucan and fiber content serving as a functional food. A number of research findings also confirmed that eating of barley foods serves as a healthy food preventing life style diseases such as diabetes, heart diseases and lowers blood cholesterol levels (McIntosh et al., 1995; Tiwari and Cummins, 2011). Similarly, Tef is also considered as a healthy food having high iron content, has slowly digestible starch and glutein free that makes ideal for glutein intolerance people. Compositional analysis and sensory quality evaluation of improved barley varieties in northern Ethiopia indicated that good quality *injera* comparable to tef could be produced (Abraha et al., 2013). This implies that barley and other cereals could be used to substitute tef or in combination with tef to make quality *injera.* Moreover, farmers in Tigray, northern Ethiopia, emphasize different traits such as grain yield, maturity and use value when choosing varieties for production and

consumption. In line with this, there is an increasing trend to use quality seeds of superior crop varieties by farmers to increase crop production and end use quality. However, despite efforts to use improved seeds including locally adapted better varieties, there have been limited studies on *injera* quality and yet still the food culture of the majority is dependent on tef *injera*. The tef dominated food habit in the urban and rural areas should be changed to a diversified food system by adopting new methods of *injera* making such as using different ratio blends of cereals (tef, barley, sorghum and maize) where consumers could get benefit nutritionally as well as economically. The study was carried out to compare a set of different crop varieties (Tef, barley, sorghum and maize) in different combination for *injera* making quality; and analyze *injera* sensory quality and consumer acceptance in relation to blend rations of the different cereals.

2. MTERIALS AND METHODS

2.1. Preparation of *injera* from cereal flour blends

Five kilo grams of quality grains were taken from selected improved varieties of Tef (variety Cimama), sorghum (variety Melkam (WSV 387)), barley (variety Fetina) and maize (variety 545 BHQPY). The grains were milled separately and one kilogram of flour was taken from each crop and used for making different blends. The flour blend ratios were: 100, 75, 50 and 25% from each variety (Tef, sorghum, barley and maize) making a 4 x 4 factorial experiment. Thick dough was prepared by adding equal amount (980 ml) of water and thoroughly kneaded by hand for about seven minutes. The dough was left to ferment at ambient room temperature about (20° C) for three days and again thoroughly mixed by adding 350 ml water to each until it reaches a uniform level of dough softness. On the fourth day boiled water (600 ml) was added to the dough, thoroughly mixed and thinned to a uniform level and the *injera* was baked on an electric clay stove at an average temperature of 170° C.

2.2. Sensory evaluation of *injera*

Sensory evaluation of *injera* was conducted at Mekelle University campus by pre-informed on the scale and procedures of sensory taste. The sensory evaluators were six males and six females from students and academic staff members with age range of 22 to 50 years. Two *injera* samples made from each variety flour blends were arranged on a flat tray (Fig 1) and were evaluated within two hours after baking. Individual evaluators were asked to compare the different blended *injera* pancakes for taste, mouth feeling, color and texture, size and distribution of gas holes on

the upper surface, and suppleness. Each participant was allowed to taste pieces of *injera* from each blend twice and rate using a scale of 1 to 5 where (1 = very poor, 2 = poor, 3 = good (less acceptable), 4 = very good (acceptable quality), and 5 = excellent, comparable to tef) for a given quality attribute. All sensory evaluations were conducted in two replications and all sensory data were recorded.

2.3. Data analysis

All the sensory data were subjected to analysis of variance using GenStat software (14[th]edition) (http://www.VSNI.co.uk) and in the model of data analysis varietal blends were considered as fixed and replications as random effects. Treatment mean comparisons were done using Duncan's multiple range tests. Treatment differences were declared at probability $P < 0.05$ level of significance. Principal component analysis (PCA) was done to study the correlation and relationship in sensory attributes and the different varietal blends using PAST statistical software version 2.17b (Hammer and Harper, 2012).

The analysis of variance model

$Y_{ij} = \mu + t_i + r_j + e_{ij}$ (i = 1, 2, …, t; j = 1, 2, … r)

Y_{ij} is a random variable observation from the ith treatment in j[th] replication,

μ, t_i & r_j are the general mean, effect of the ith treatment & effect of the jth replication, and e_{ij} is the error component.

Figure 1. Sensory evaluation of *Injera* made from different cereal flour blends at Mekelle University.

3. RESULTS AND DISCUSSION

The study has shown significant differences among the different cereal flour blends in sensory quality attributes such as texture, mouth feeling, suppleness and overall rating, while the appearance of surface gas holes, color and taste of *injera* made from the different cereal flour blends were non- significant at p-value of 5% level. Comparing the sensory preference results has revealed that *injera* made from sole tef has got the highest average preference scores in texture, mouth feeling, suppleness and overall rate. *Injera* made from a blend of tef + barley in 50:50 ratio was the second best comparable to tef in texture, mouth feeling and suppleness followed by tef + sorghum, tef + maize in 50:50 blend ratio, and tef + barley + sorghum (ABC) in 33% ratio each (Table 1). Similarly, *injera* made from the three equal flour blend ratios (33%) of each: tef + barley + maize (ABD), tef + sorghum + maize (ACD) and *injera* made from all four varietal blends (ABCD) in equal proportions (25%) from each produced acceptable *injera* quality comparable to the second group ranked as very good (Table 1). On the other hand *injera* made from sole sorghum, maize, and blend of barley + sorghum, barley + maize and sorghum + maize in 50:50 ratios and a blend from barley + sorghum + maize (BCD) produced a third group ranked as good but was relatively less preferred *injera* quality for most of the sensory attributes (*injera* texture, mouth feeling, suppleness, taste, overall rate). Although it was not significantly different, *injera* made from sorghum, maize, barley + sorghum blend and tef + sorghum + maize had better preference score in *injera* colour and surface gas holes. From the overall ranking, *injera* made from sole tef was the best followed by *injera* made from a blend of tef + barley + sorghum; tef + maize; tef + sorghum + maize, and from the four varietal blends (ABCD) table 1. Most of the sensory traits showed a significant ($P < 0.05$) positive correlation ($r>0.71$) with each other except for *injera* colour. *Injera* texture was positively ($P < 0.05$) correlated with *injera* mouth feeling, taste, suppleness and overall rate rank, but it was not correlated significantly with surface gas holes and colour. While *injera* surface gas holes showed a significant positive correlation ($p<0.05$) with *injera* taste and overall rate. Although statistically not significant, the preference score for *injera* colour was higher in sole sorghum, barley + sorghum, tef + sorghum + maize (ACD), and the four varietal blends (ABCD) than sole tef and other blends (Table 1). Sensory result of the principal component analysis (PCA) revealed that the sensory attributes and preferred *injera* blends were displayed to the right quadrant of the bi-plot with tef being the leading best preferred, while poor or less preferred *injera* blends are displayed on the left

quadrant of the bi-plot (Fig 2). The PC1 explained 65.84% of the variation in the sensory quality analysis while PC2 explained only 19.12% of the variation among the different varietal blends. The PCA bi-plot (Fig 2) results also showed a clear relationship on preference for *injera* quality.

Table 1. *Injera* sensory evaluation results of the different varietal flour blends.

S.No	Flour type/blend	Injera Sensory attributes						
		Surface gas holes	Colour	Texture	Mouth feeling	Taste	Suppleness	Overall Rate
1	A (Tef = 100%)	4.3	3.3	4.6a	4.6a	4.2	4.2 a	4.4a
2	B (Barley = 100%)	3.4	3.7	3.4 cd	3.7bcd	3.2	3.5 bc	3.3 bcde
3	C (Sorghum =100%)	3.7	3.7	2.6 ef	2.8h	3.1	3.2 bcd	2.9 bcdef
4	D (Maize = 100%)	3.7	3.2	2.5 ef	3.2 defgh	2.6	2.4 e	2.7 def
5	AB (50:50)	3.3	2.7	4.1 ab	3.9b	3.2	3.7ab	3.0 bcdef
6	AC (50:50)	3.3	3.5	3.8 bc	3.9bc	3.7	3.3 bcd	3.4 bcd
7	AD (50:50)	3.6	3.5	3.8 bc	3.6 bcde	3.6	3.5 bc	3.6 abc
8	BC (50:50)	3.3	3.7	3.3 cd	3.2 defgh	3.1	3.4 bcd	2.8 cdef
9	BD (50:50)	1.9	3.1	3.1 de	2.9 gh	2.7	2.8 de	2.4 f
10	CD (50:50)	3.4	3.2	2.4 f	3.0 fgh	3.3	2.8 de	2.9 bcdef
11	ABC (33:33:33)	3.5	3.3	3.9 bc	3.8 bc	3.6	3.5 bc	3.6 ab
12	ABD (33:33:33)	3.0	3.4	3.4 cd	3.5 bcdef	3.2	3.3 bcd	3.2 bcdef
13	ACD (33:33:33)	3.8	3.7	3.3 cd	3.3cdefgh	3.6	3.5 bc	3.5 bcd
14	BCD (33:33:33)	2.9	3.4	2.9 def	3.1 efgh	3.2	2.9 cde	2.6 def
15	ABCD (25:25:25:25)	3.5	3.7	3.4 cd	3.4 bcdefg	3.5	3.5 bc	3.4 bcd
	Mean	3.37	3.4	3.37	3.46	3.2	3.3	3.2
	CV (%)	17.7	9.1	7.8	7.8	12.5	8.5	12.5
	P-value	ns	ns	0.001	0.001	ns	0.003	0.02

Note: Ns= non-significant at p-value ≤0.05 level.

Injera made from sole sorghum (100%) and sole maize has got the lowest preference scores for most of the quality attributes except for color and surface gas holes. This is clearly displayed in the bi-plot (Fig 2) where the flat bread made from maize and sorghum was displayed to the left quadrant indicating less overall preference rate.

From the study *injera* texture, mouth feeling, suppleness and overall rate were the main determinants for the *injera* preference and acceptability ranking differences. But the overall sensory quality ranking was less affected by taste, color and surface gas holes differences. This might be because there was less variation in taste, colour and surface gas holes among the

different flour blends. Moreover, varieties with different colors such red tef and black seeded barley were not included in the study.

The sensory quality evaluation results has demonstrated that *injera* made from tef had an excellent preference score as expected, and very good *injera* quality was also obtained from the other different varietal blends with tef. This implies that *injera* made from varietal blends could be used as a substitute to tef in the towns with reasonably fair cost and better nutritional value. While in rural areas farmers have some experience in consuming *injera* made from two or more different varietal blends, and the blend ratios they used depends on the availability of cereal grains in the households.
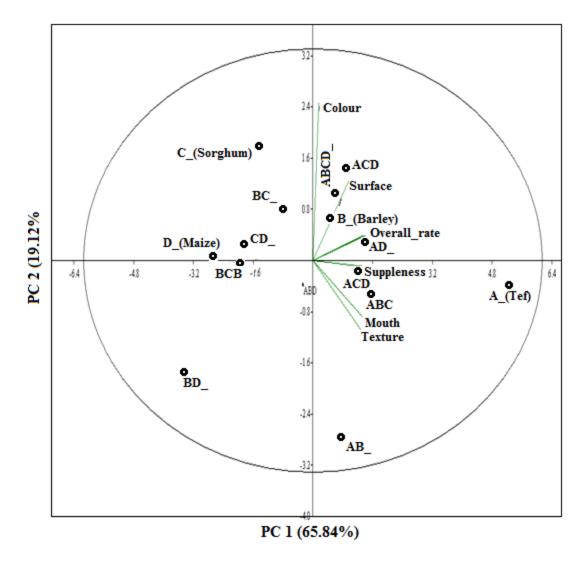

Figure 2. Biplot of *injera* sensory attributes of different varietal blends.

With the increasing population growth and rising demands to use for quality *injera*, using available cereals for *injera* making with tef or other cereals that give consumers preferred acceptable quality from best varietal blends is crucial to achieve food and nutritional security to the subsistence farmers. Considering the importance of *injera* in the majority of Ethiopians food habit serving as a major source of energy, our sensory evaluation findings could be used and adopted both in rural and urban populations using the available cereal grains even under the existing impact of climate change on crop production in the country. In the present study the quality and acceptability of *injera* are dependent on the type of varieties used in the experiment because varietal difference could have an impact on *injera* quality. Other research reports also indicated that the acceptability and quality of *injera* is affected by the varietal differences as reported by Gebrekidan and Gebrehiwot (1982) who reported poor quality *injera* with less gas holes was found in some sorghum varieties and indicated that the poor quality *injera* in sorghum was due to sticky texture, bitter taste, and high tannin content. Zegeye (1997) also reported significant difference in acceptability of *injera* made from tef, sorghum, baley and maize cultivars.

Study on sensory quality evaluation of *injera* made from different barley varieties Abraha et al. (2013) reported that a very good quality *injera* comparable to tef was produced from improved barley varieties in Tigray, northern Ethiopia. The same report also indicated that sensory quality differences are governed mainly by varietal inherent differences with less impact from environmental factors. Yetneberk et al. (2005) also reported that decortication of sorghum and compositing with tef improved *injera* quality. In the study of *injera* made from tef, Parker et al. (1989) reported that tef starch played a major role in the formation of *injera* surface gas holes. In the current study, the non-significant difference results in *injera* surface gas holes, colour and taste indicates that preference ranking among the *injera* evaluators for these traits was more or less similar. This may indicate the effect of these sensory attributes was lower in determination of the overall *injera* ranking.

4. CONCLUSION

From the current study the very good *injera* sensory results obtained from Tef + barley, tef + sorghum, and tef + maize in 50:50 blend, and tef + barley + sorghum (33% each) implies that these varietal blends could be used as substitutes to the sole tef *injera* both in the urban towns

and in the rural communities. Moreover, consumers could be benefited from the use of *injera* made from these different cereal flour blends due to their enhanced nutritional contents besides the economic advantage due to lower prices compared to that of tef. As a recommendation, results of the current study could be disseminated and up scaled through participatory demonstration trials to wider consumers. This study results were from sensory preference test only, hence further investigation on compositional and starch pasting prosperities may be needed to supplement information on *injera* sensory quality results.

5. ACKNOWLEDGMENTS

6. REFERENCE

ATA. 2015. Ethiopian Agricultural Transformation Agency, Progress Report 2011-2015, Growth and Transformation Period I. Ethiopian Agricultural Transformation Agency, Addis Ababa Ethiopia, 59p.

Abraha, A., Uhlen, A.K., Abay F., Stefan, S & Åsmund,B. 2013. Genetic Variation in Barley Enables a High Quality Injera, the Ethiopian Staple Flat Bread, Comparable to Tef. Crop Science 53:1-11. DOI: 10.2135/cropsci2012.11.0623.

Central Statistical Agency (CSA). 2017a. Total Population size, Addis Ababa, Ethiopia: http://www.csa.gov.et/index.php/ehioinfo-internal

Central Statistical Agency (CSA). 2017b. Agricultural sample survey 2016/2017 (2009 E.C.) statistical buletin on Area and Production of major Crops (Private Peasant Holdings, Meher season), Central Statistical Agency, Addis Ababa, Ethiopia.

Gebrekidan, B & Gebrehiwot, B. 1982. Sorghum injera preparations and quality parameters. In: L. W. Rooney and D. S. Murty (Eds.), Proceedings of the International Symposium on Sorghum Grain Quality, ICRISAT, Patanceru, India, pp. 55-66.

Hammer, O & Harper, D. 2012. PAST: Paleontological Statistical software package for education and data analysis (PAST version 2.17b). http:folk.uio.no/ohammer/past

http://www.vsni.co.uk. GenStat software 14th Edition for bioscience VSN International, United Kingdom.

McIntosh, G.H., Newman, R.K & Newman, C.W. 1995. Barley foods and their influence on cholesterol metabolism. *World Review of Nutrition Diet*, **77**:89-108.

Parker, M.L., Umeta, M & Faulks, R.M. 1989. The Contribution of Flour Components to the Structure of Injera, an Ethiopian Fermented Bread made from Tef (*Eragrostis tef*). *Journal of Cereal Science*, **10**:93-104.

Tiwari, U & Cummins, E. 2011. Meta-analysis of the effect of beta-glucan intake on blood cholesterol and glucose levels. *Nutrition*, **27**:1008-16. DOI: 10.1016/j.nut.2010.11.006.

Yetneberk, S., deKock, H.L., Rooney, L.W & Taylor, J.R.N. 2004. Effects of sorghum cultivar on injera quality. *Cereal Chem.*, **8**:314–321. doi:10.1094/CCHEM.2004.81.3.314.

Yetneberk, S., Rooney, L.W & Taylor, J.R. 2005. Improving the quality of sorghum injera by decortication and compositing with tef. *Journal of the Science of Food and Agriculture*, **85**:1252-1258. DOI: 10.1002/jsfa.2103.

Zegeye, A. 1997. Acceptability of Injera with Stewed Chicken. *Food quality and Preference*, **8**:293-295.